SERIEs (2015) 6:349–360
DOI 10.1007/s13209-015-0128-z

ORIGINAL ARTICLE

Voting over law enforcement: mission impossible

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Received: 9 March 2014 / Accepted: 13 July 2015 / Published online: 24 July 2015

Abstract Median voter theorem has been used in many economic environments including law enforcement. Assumptions of the median voter theorem, however, are generally violated in law enforcement models. Moreover, it is impossible to have agents with "opposite equilibrium preferences" over enforcement levels in law enforcement models. These limitations on the use of preferences over law enforcement raises questions about the robustness and validity of law enforcement models.

Keywords Public enforcement · Equilibrium preferences · Enforcement equilibrium · Median voter theorem · Single-peaked preferences · Single-crossing property

JEL Classification D62 · D7 · K14 · K42

1 Introduction

Law enforcement is among the key elements of a civil society that ensures the achievement of a higher social welfare. Since Becker (1968) has introduced an economic analysis of law enforcement, there has been a vast literature on economics of crime

I am grateful to the late Leo Hurwicz, Andy McLennan, the late Ket Richter, Jan Werner and the participants of the Micro/Finance Workshop at the University of Minnesota. I also would like to thank the Editor-in-Chief Nezih Guner and an anonymous referee of the journal for their useful comments, which significantly improved the exposition of the paper. All errors are mine.

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and punishment.[1] In public enforcement of law models, the state determines the level of enforcement expenditures, hence the probability of detecting violators, and fines for harmful acts. Then, the law enforcement monitors the activities of agents, detects and fines the violators. As the enforcement expenditures increase, the likelihood of violators being detected and fined increases.

There are various ways the state can determine the enforcement expenditures as well as fines. One recent approach is to use majority voting. In the majority voting, policy x is socially preferred to policy y if there is a majority of voters who prefer x to y. The median voter theorem states that if preferences satisfy single-peakedness, then the most preferred alternative of the resulting social preference coincides with the most preferred alternative of the median voter (Black 1948; Moulin 1980). An alternative characterization of the aforementioned median voter theorem is given in Gans and Smart (1996) using the single-crossing property on preference profiles. Traxler (2009, 2012), Besfamille et al. (2013), and Bethencourt and Kunze (2015) apply the median voter theorem to the tax enforcement problem to determine the enforcement level. In the context of enforcement of illegal immigration, Garca (2006), and Facchini and Testa (2014) use the median voter theorem to determine the enforcement level. These aforementioned authors either use single-peaked preferences assumption[2] or single-crossing property[3] of preference profiles to be able to apply the median voter theorem.

In this paper, I question the applicability of the median voter theorem to the law enforcement problem to determine either one of the two dimensions of the enforcement level. I show that the use of preferences over enforcement levels (enforcement expenditures as well as fines) has important limitations. I derive individual equilibrium preferences over enforcement levels (enforcement expenditures and fines) in a specific enforcement environment (see Polinsky and Shavell 1984) and over enforcement expenditures in a general enforcement environment (see Polinsky and Shavell 1992). In the specific enforcement model, there is one harmful act agents can take, and the enforcement agency monitors agents, detects violators with some probability, and fines them. On the other hand, in the general enforcement model, there are various acts, and each agent commits one of these acts. The enforcement agency monitors all of these acts, detects violators of all kinds with some probability, and fines them at levels depending on harms caused by their acts. In an enforcement equilibrium (of both of these models), given the enforcement level (fines and the enforcement expenditure, which determines the level of monitoring/detection), each agent decides whether to engage in the harmful act. Given the level of enforcement, an agent's expected utility depends not only on his own action but also on actions of other agents. This is because other agents' actions determine the harm he faces, and affect fine revenues used to finance public enforcement along with taxes collected.

Example 1 in Sect. 2 gives a range of agents' benefits (from the harmful act) who have double-peaked preferences, violating the single-peakedness condition sufficient for the existence of a majority voting equilibrium in the median voter theorem.

[1] See Polinsky and Shavell (2000) and Polinsky and Shavell (2007) for recent literature surveys.

[2] See Black (1948) and Moulin (1980).

[3] See, for example, Gans and Smart (1996) on the sufficiency of single-crossing property for the existence of a majority voting equilibrium.

Moreover, single-crossing property of preference profiles, which is also sufficient for the existence of a majority voting equilibrium, is also violated. The example is quite general and hence it provides insight to problems with these assumptions in law enforcement models. Theorem 1 shows that in the specific enforcement model, in any society it is impossible to have agents with opposite equilibrium preferences over enforcement expenditure or fine level, i.e., in equilibrium, if there is an agent who prefers higher enforcement expenditure (fine level) to less, then there cannot be another agent in the same society who prefers less enforcement expenditure (fine level) to a higher one. In the general enforcement model, Theorem 2 shows that in any society it is impossible to have agents with opposite equilibrium preferences over enforcement expenditure, i.e., in equilibrium, if there is an agent who prefers higher enforcement expenditure to less, then there cannot be another agent in the same society who prefers less enforcement expenditure to a higher one.

In order to determine the enforcement levels (enforcement expenditures and fines), alternative objectives for the state have been proposed in the economics of law enforcement literature. For example, in Becker (1968) the objective of social planner is to minimize social cost, which consists of harms caused by agents, costs of detection, and the costs of punishment to the criminals less gains of criminals. Agents and their choices are implicitly explained, and they get utility from consumption, and face uncertainty because of the possibility of getting caught. Cooter and Ulen (2008) (p.510) suggest that the aim of the law maker is to minimize social cost but it consists of costs of protection and the net harm caused, i.e. social loss, while the crime is committed. In Polinsky and Shavell (1984),[4] on the other hand, the objective of the law maker is to maximize total expected utility of agents in the society. The expected utility of an agent consists of his gain from engaging in the harmful activity, expected loss due to the possibility of getting caught, expected loss due to the possibility of being a victim of a crime, and the per capita cost of enforcement. If the agent does not engage in the harmful activity, then the expected utility will not include the gain from engaging in harmful the activity, and the expected punishment.

In Sect. 2, the specific enforcement model, including the formal definitions of enforcement equilibrium, equilibrium expected utility, and the results in this environment are given. Example 1 in Sect. 2 shows violations of single-peakedness and single-crossing property. General enforcement model and the main result in this model are given in Sect. 3.

2 Specific enforcement model

There is a unit measure of agents in the society. Each agent $i \in [0, 1]$ is risk neutral, and decides whether to engage in an act to receive benefit of $v_i > 0$ and cause harm $h > 0$, which is the same across all agents. Benefits of agents in the society are distributed with $g(\cdot)$, a continuous probability density function, and a cumulative distribution function $G(\cdot)$. Law enforcement monitors the actions of agents and detects each agent engaging in the harmful act with probability $p(c) \in [0, 1]$ when

[4] See also Polinsky and Shavell (1979).

the enforcement expenditure is c. Probability of detection $p(\cdot)$ is assumed to be a continuously differentiable increasing function of enforcement expenditure c, i.e. $p' > 0$. If an agent is detected committing the act, he then pays a fine of f. The fine level f does not exceed any agent's budget w, i.e. $f \in [0, w]$. Enforcement level (c, f) is a pair of enforcement expenditure c and fine f. The revenue from the fines collected at enforcement expenditure c is assumed to be equally shared by all agents in the society. Given the probability of detection $p(c)$ and fine level f, each agent i engages in the harmful activity if $v_i \geq p(c)f$ and receives the net benefit of $v_i - p(c)f$. If $v_i < p(c)f$, then he does not engage in the harmful activity, and receives 0.

Given enforcement level $(c, f) \in [0, \infty) \times [0, w]$, each agent i has equilibrium expected utility[5]

$$Eu_i^* = \max\{0, v_i - p(c)f\} - h \int_{p(c)f}^{\infty} g(v)\mathrm{d}v - c + p(c)f \int_{p(c)f}^{\infty} g(v)\mathrm{d}v. \quad (1)$$

While the expression $p(c)f \int_{p(c)f}^{\infty} g(v)\mathrm{d}v$ is the revenue from fines collected at enforcement level (c, f), the expression $h \int_{p(c)f}^{\infty} g(v)\mathrm{d}v$ has two possible interpretations: If the harm is a public harm, meaning all agents are affected by each harmful activity, then $h \int_{p(c)f}^{\infty} g(v)\mathrm{d}v$ is the total harm in the society caused by agents engaged in the harmful activity at enforcement level (c, f). If the harm is a private harm, meaning a random agent is offended by each harmful activity, and each agent is equally likely to be affected by each harmful activity, then $h \int_{p(c)f}^{\infty} g(v)\mathrm{d}v$ is the expected total harm each agent faces caused by agents engaged in the harmful activity at enforcement level (c, f).[6]

Given the probability of detection $p(c)$ and fine level f, an enforcement equilibrium is a set of actions $\{a_i^*\}_{i\in[0,1]}$ such that for each agent i action a_i^*, which represents engaging or not engaging in the act, maximizes his utility. Observe that when equilibrium expected utility in Eq. 1 is integrated over all agents, the resulting equation is the social welfare in the society

$$\int_{p(c)f}^{\infty} (v - h)\, g(v)\mathrm{d}v - c$$

and it is identical to the social welfare in Polinsky and Shavell (2007), Equation 13.

Lemmas 1 and 2 below show that for any two agents, their marginal equilibrium expected utilities are identical at enforcement levels (c, f) where they make the same decision about engaging in harmful activity.

Lemma 1 *Given fine level f, for each agent $i, j \in [0, 1]$ such that $v_i < v_j$, and for each level of enforcement expenditure c such that $p(c)f \in (0, v_i) \cup (v_j, \infty)$, marginal*

[5] I would like to thank Andy McLennan for suggesting this term.

[6] For more on private versus public harms see, for example, Bator (1958), Head (1962), and Baumol and Oates (1988).

equilibrium expected utilities of agents i and j with respect to c are equal, i.e.

$$\frac{\partial Eu_i^*}{\partial c} = \frac{\partial Eu_j^*}{\partial c},$$

and for each c such that $p(c)f \in (v_i, v_j)$

$$\frac{\partial Eu_i^*}{\partial c} > \frac{\partial Eu_j^*}{\partial c}.$$

Proof Observe that from Eq. 1 for each agent $i \in [0, 1]$, his marginal equilibrium expected utility with respect to c at each enforcement level (c, f) such that i engages in the harmful activity, i.e. $p(c)f < v_i$, is

$$\frac{\partial Eu_i^*}{\partial c} = \big(p'(c)\, f\big)\big[\big(h - p(c)\, f\big)\, g\big(p(c)\, f\big) - G\big(p(c) f\big)\big] - 1,$$

and his marginal equilibrium expected utility with respect to c at each enforcement level (c, f) such that i does not engage in the harmful activity, i.e. $p(c)\, f > v_i$, is

$$\frac{\partial Eu_i^*}{\partial c} = \big(p'(c)\, f\big)\big[\big(h - p(c)\, f\big)\, g\big(p(c)\, f\big) + 1 - G\big(p(c) f\big)\big] - 1.$$

Hence, if $p(c)f \in (0, v_i) \cup (v_j, \infty)$, then agents i and j have identical marginal equilibrium expected utilities, i.e.

$$\frac{\partial Eu_i^*}{\partial c} = \frac{\partial Eu_j^*}{\partial c}.$$

Observe that since $p' > 0$, if $p(c)f \in (v_i, v_j)$, then

$$\frac{\partial Eu_i^*}{\partial c} > \frac{\partial Eu_j^*}{\partial c}.$$

□

Lemma 2 *Given enforcement expenditure c, for each agent* $i, j \in [0, 1]$ *such that* $v_i < v_j$, *and for each level of fine f such that* $p(c)f \in (0, v_i) \cup (v_j, \infty)$, *marginal equilibrium expected utilities with respect to f of agents i and j are equal, i.e.*

$$\frac{\partial Eu_i^*}{\partial f} = \frac{\partial Eu_j^*}{\partial f},$$

and for each $p(c)f \in (v_i, v_j)$

$$\frac{\partial Eu_i^*}{\partial f} > \frac{\partial Eu_j^*}{\partial f}.$$

Proof Observe that from Eq. 1 for each agent $i \in [0, 1]$, his marginal equilibrium expected utility with respect to f at enforcement level (c, f) such that i engages in the harmful activity, i.e. $p(c)f < v_i$, is

$$\frac{\partial Eu_i^*}{\partial f} = p(c)\left[(h - p(c)\,f)\; g\left(p(c)\,f\right) - G\left(p(c)f\right)\right],$$

and his marginal equilibrium expected utility at each enforcement level (c, f) such that i does not engage in the harmful activity, i.e. $p(c)\,f > v_i$, is

$$\frac{\partial Eu_i^*}{\partial f} = p(c)\big[\big(h - p(c)\,f\big)\,g\big(p(c)\,f\big) + 1 - G\big(p(c)f\big)\big].$$

Hence, if $p(c)f \in (0, v_i) \cup (v_j, \infty)$, then agents i and j have identical marginal equilibrium expected utilities, i.e.

$$\frac{\partial Eu_i^*}{\partial f} = \frac{\partial Eu_j^*}{\partial f}.$$

Observe that if $p(c)f \in (v_i, v_j)$, then

$$\frac{\partial Eu_i^*}{\partial f} > \frac{\partial Eu_j^*}{\partial f}.$$

□

Lemmas 1 and 2 imply that for each agent $i, j \in [0, 1]$ such that $v_i < v_j$, and at each enforcement expenditure c and fine level f such that $p(c)f \in [0, v_i) \cup (v_j, \infty)$, equilibrium expected utilities of i and j change in the same direction when c or f changes. An immediate consequence of these lemmas, Theorem 1 below states that in a given society, in equilibrium there do not exist two agents such that when one always prefers higher monitoring (fine) to lower monitoring (fine), the other always prefers lower monitoring (fine) to higher monitoring (fine). Hence, the impossibility of the existence of opposite equilibrium preferences on law enforcement emerges.

Theorem 1 *There do not exist agents* $i, j \in [0, 1]$ *such that agent* i*'s equilibrium expected utility is monotone increasing in enforcement expenditure* c *(fine* f*) whereas agent* j*'s equilibrium expected utility is monotone decreasing in enforcement expenditure* c *(fine* f*).*

According to the median voter theorem, the median voter's most preferred alternative is the winner of the majority voting on each pair of alternatives. There are two conditions frequently used in the literature for the median voter theorem: Single-peakedness condition on preferences, and single-crossing property of preference profiles: Agent i has single-peaked preferences (in the current environment) if there exists an alternative c such that for each $c' < c'' < c$ or $c' > c'' > c$, $Eu_i^*(c') < Eu_i^*(c'') < Eu_i^*(c)$. A preference profile satisfies *single-crossing property* (in the current environment) if for each alternative $c' > c$ and for each agent

$v_{i'} > v_i$, $Eu_i^*(c') \geq Eu_i^*(c)$ implies that $Eu_{i'}^*(c') \geq Eu_{i'}^*(c)$, and $Eu_i^*(c') > Eu_i^*(c)$ implies that $Eu_{i'}^*(c') > Eu_{i'}^*(c)$. The example below provides insight to the nature of violation of these conditions in the enforcement environment.

Example 1 Let the probability of detection be $p(c) = c$, and the probability distribution of values be $g(v) = \frac{10-v}{50}$ for $v \in [0, 10]$ and $g(v) = 0$ for $v \notin [0, 10]$. Then, agent i's equilibrium expected utility at enforcement level (c, f) is

$$\begin{aligned} Eu_i^* &= \max\{0, v_i - cf\} - c - h \int_{cf}^{10} \left(\frac{10-v}{50}\right) \mathrm{d}v + cf \int_{cf}^{10} \left(\frac{10-v}{50}\right) \mathrm{d}v \\ &= \max\{0, v_i - cf\} - c + (cf - h)\frac{(10-cf)^2}{100}. \end{aligned}$$

Assume that the harm level $h = 3$ and fine level $f = 7$. For any agent, the peak of his preferences (the maximum of the equilibrium expected utility function) is at $c_1^* \approx 0.15$ if he decides to involve in the harmful act, and the peak is at $c_2^* \approx 0.63$ if he decides not to involve in the act. For any agent i such that $v_i \leq c_1^* f$ or $v_i \geq c_2^* f$, agent i has single-peaked preferences over enforcement expenditure c such that for each $c \leq \frac{v_i}{f}$, $Eu_i^* = v_i - cf - c + (cf - h)\frac{(10-cf)^2}{100}$, and for each $c \geq \frac{v_i}{f}$, $Eu_i^* = -c + (cf - h)\frac{(10-cf)^2}{100}$. For any agent i such that $v_i \in (c_1^* f, c_2^* f)$, agent i has double-peaked preferences over enforcement expenditure c. Moreover, single-crossing property is not satisfied either: for $v_i = 0.1$, $Eu_i^*(0.4) > Eu_i^*(0.3)$, but for $v_j = 3.5 > v_i$, $Eu_i^*(0.4) < Eu_i^*(0.3)$.

3 General enforcement

In the general enforcement model (see Polinsky and Shavell (1992)), agents are risk-neutral and they choose whether to commit a harmful act or not. Agent $i \in [0, 1]$ receives benefit $v_i \geq 0$ from the act, and benefits are randomly distributed with an integrable probability density function $g(\cdot)$ whose cumulative distribution function is $G(\cdot)$. The harm caused by agent i's act, $h_i \geq 0$ is randomly distributed with an integrable probability density function $r(\cdot)$ whose cumulative distribution function is $R(\cdot)$. Distributions $g(\cdot)$ and $r(\cdot)$ are assumed to be independent. Fine schedule $f(\cdot)$ assigns a fine to each harm level h such that $0 \leq f(h) \leq w$, where w represents agents' wealth.

When the expenditure on enforcement is $c \geq 0$, the probability of detection is $p(c) \in [0, 1]$. When agent i is caught (with probability $p(c)$), he pays a fine $f(h_i)$. In addition to the fixed cost c of enforcement, there is also variable cost of enforcement, $k \geq 0$. Whenever an offender is caught, k is the cost of fining that agent. Given the probability of detection $p(c)$ and the fine schedule $f(\cdot)$, agent i decides to commit an act if $v_i \geq p(c)f(h_i)$.

Given the enforcement expenditure c, social welfare in this model (see Polinsky and Shavell 1992, Eq. 2) is

$$\int_0^\infty \int_{p(c)\,f(h)}^\infty (v - h - p(c)\,k)\,g(v)\,r(h)\,\mathrm{d}v\,\mathrm{d}h - c. \tag{2}$$

Given the probability of detection $p(c)$, the optimal fine schedule $f(\cdot)$ is such that for each harm level h it maximizes

$$\int_{p(c)\,f(h)}^\infty (v - h - p(c)\,k)\,g(v)\,\mathrm{d}v.$$

Hence, by Polinsky and Shavell (1992) (Proposition 1) the optimal fine schedule is

$$f^*(h_i) = \begin{cases} k + \frac{h_i}{p(c)} & \text{if } h_i \le p(c)\,(w - k), \\ w & \text{if } h_i > p(c)\,(w - k). \end{cases} \tag{3}$$

Observe that given the enforcement expenditure c, the optimal fine schedule $f^*(\cdot)$ is strictly monotone increasing in harm levels up to some level after which fines of all harms equal w.

Given enforcement expenditure c, social welfare in Eq. 2 becomes (see Polinsky and Shavell 1992, Eq. 5)

$$\int_0^{p(c)\,(w-k)} \int_{h+p(c)\,k}^\infty (v - h - p(c)\,k)\,g(v)\,r(h)\,\mathrm{d}v\,\mathrm{d}h + \int_{p(c)\,(w-k)}^\infty \int_{p(c)\,w}^\infty (v - h - p(c)\,k)\,g(v)\,r(h)\,\mathrm{d}v\,\mathrm{d}h - c.$$

Given the probability of detection $p(c)$ and the corresponding optimal fine schedule $f^*(\cdot)$ from Eq. 3, agent i benefiting v_i from the act and causing the harm h_i commits the act if $v_i \ge p(c)\,f^*(h_i)$. So, agent i's equilibrium expected utility is

$$\begin{aligned} Eu_i^* &= \max\{0, v_i - p(c)\,f^*(h_i)\} \\ &+ \int_0^{p(c)\,(w-k)} \int_{h+p(c)\,k}^\infty (-h - p(c)\,k + p(c)\,f^*(h))\,g(v)\,r(h)\,\mathrm{d}v\,\mathrm{d}h \\ &+ \int_{p(c)\,(w-k)}^\infty \int_{p(c)\,w}^\infty (-h - p(c)\,k + p(c)\,f^*(h))\,g(v)\,r(h)\,\mathrm{d}v\,\mathrm{d}h - c. \end{aligned} \tag{4}$$

Proposition 1 below gives the equilibrium expected utility when the optimal fine schedule $f^*(\cdot)$ is substituted into Eq. 4.

Proposition 1 *Each agent i's equilibrium expected utility is*

$$
\begin{aligned}
Eu_i^* &= \max\{0, v_i - p(c)\, f^*(h_i)\} \\
&\quad + \Big(1 - G\big(p(c)\, w\big)\Big) \left[p(c)\,(w-k)\Big(1 - R\big(p(c)\,(w-k)\big)\Big) \right. \\
&\quad \left. - \int_{p(c)\,(w-k)}^{\infty} h\, r(h)\, \mathrm{d}h \right] - c.
\end{aligned} \tag{5}
$$

Proof By Eqs. 3 and 4,

$$
\begin{aligned}
Eu_i^* &= \max\{0, v_i - p(c)\, f^*(h_i)\} \\
&\quad + \int_0^{p(c)\,(w-k)} \int_{h+p(c)\,k}^{\infty} (-h - p(c)\,k + h + p(c)\,k)\, g(v)\, r(h)\, \mathrm{d}v\, \mathrm{d}h \\
&\quad + \int_{p(c)\,(w-k)}^{\infty} \int_{p(c)\,w}^{\infty} (-h - p(c)\,k + p(c)\,w)\, g(v)\, r(h)\, \mathrm{d}v\, \mathrm{d}h - c \\
&= \max\{0, v_i - p(c)\, f^*(h_i)\} \\
&\quad + \int_{p(c)\,(w-k)}^{\infty} \int_{p(c)\,w}^{\infty} (-h - p(c)\,k + p(c)\,w)\, g(v)\, r(h)\, \mathrm{d}v\, \mathrm{d}h - c \\
&= \max\{0, v_i - p(c)\, f^*(h_i)\} \\
&\quad + [1 - G(p(c)\,w)] \int_{p(c)\,(w-k)}^{\infty} (-h - p(c)\,k + p(c)\,w)\, r(h)\, \mathrm{d}h - c \\
&= \max\{0, v_i - p(c)\, f^*(h_i)\} \\
&\quad + \Big(1 - G\big(p(c)\, w\big)\Big) \left[p(c)\,(w-k)\Big(1 - R\big(p(c)\,(w-k)\big)\Big) \right. \\
&\quad \left. - \int_{p(c)\,(w-k)}^{\infty} (h)\, r(h)\, \mathrm{d}h \right] - c.
\end{aligned}
$$

□

Lemma 3 *Given fine level f, for each agent $i,\ j \in [0,1]$ and for each level of enforcement expenditure c satisfying one of the following conditions:*

(i) $h_i, h_j > p(c)(w-k)$ *and* $v_i, v_j \geq p(c)w$,
(ii) $h_i, h_j \leq p(c)(w-k)$ *and* $v_i \geq p(c)k + h_i$ *and* $v_j \geq p(c)k + h_j$,
(iii) $v_i, v_j < p(c)w$,

marginal equilibrium expected utilities of agents i and j with respect to c are equal, i.e.

$$\frac{\partial Eu_i^*}{\partial c} = \frac{\partial Eu_j^*}{\partial c}.$$

Proof From Eq. 5

$$\begin{aligned}
\frac{\partial Eu_i^*}{\partial c} &= \frac{\partial \max\{0, v_i - p(c)\, f^*(h_i)\}}{\partial c} \\
&\quad + \Big(-p'(c)\, wg\big(p(c)\, w\big)\Big)\Big[p(c)\,(w-k)\Big(1 - R\big(p(c)\,(w-k)\big)\Big) \\
&\quad - \int\limits_{p(c)\,(w-k)}^{\infty} h\, r(h)\, \mathrm{d}h\Big] \\
&\quad + \Big(1 - G\big(p(c)\, w\big)\Big)\Big[(w-k)p'(c)\Big(1 - R\big(p(c)\,(w-k)\big)\Big) \\
&\quad + p(c)\,(w-k)\,\Big(-p'(c)\,(w-k)\, r\big(p(c)\,(w-k)\big)\Big) \\
&\quad + p(c)\,(w-k)\, r\big(p(c)\,(w-k)\big)\, p'(c)\,(w-k)\Big] - 1 \\
&= \frac{\partial \max\{0, v_i - p(c)\, f^*(h_i)\}}{\partial c} \\
&\quad - \Big(p'(c)\, w\, g\big(p(c)\, w\big)\Big)\left[p(c)\,(w-k)\,\Big(1 - R\big(p(c)\,(w-k)\big)\Big)\right. \\
&\quad \left. - \int\limits_{p(c)\,(w-k)}^{\infty} h\, r(h)\, \mathrm{d}h\right] \\
&\quad + \Big(1 - G\big(p(c)\, w\big)\Big)\Big[(w-k)\, p'(c)\Big(1 - R\big(p(c)\,(w-k)\big)\Big)\Big] - 1.
\end{aligned}$$

Observe that if condition i. holds, then

$$\frac{\partial \max\{0, v_i - p(c)\, f^*(h_i)\}}{\partial c} = \frac{\partial \max\{0, v_j - p(c)\, f^*(h_j)\}}{\partial c} = -p'(c)w,$$

if condition ii. holds, then

$$\frac{\partial \max\{0, v_i - p(c)\, f^*(h_i)\}}{\partial c} = \frac{\partial \max\{0, v_j - p(c)\, f^*(h_j)\}}{\partial c} = -p'(c)k,$$

and if condition iii. holds, then

$$\frac{\partial \max\{0, v_i - p(c)\, f^*(h_i)\}}{\partial c} = \frac{\partial \max\{0, v_j - p(c)\, f^*(h_j)\}}{\partial c} = 0.$$

Since by Eq. 5 $\frac{\partial Eu_i^*}{\partial c} - \frac{\partial \max\{0, v_i - p(c)\, f^*(h_i)\}}{\partial c}$ is equal for all agents, the result holds. □

Theorem 2, an immediate consequence of Lemma 3, states that in a given society, in equilibrium there do not exist two agents such that when one always prefers higher monitoring to lower monitoring, the other always prefers lower monitoring to higher monitoring. Hence, the impossibility of the existence of opposite equilibrium preferences on law enforcement emerges in the general enforcement model as well.

Theorem 2 *There do not exist agents* $i, j \in [0, 1]$ *such that agent* i*'s equilibrium expected utility is monotone increasing in enforcement expenditure* c *whereas agent* j*'s equilibrium expected utility is monotone decreasing in enforcement expenditure* c.

4 Conclusion

Majority voting is one of the methods used in many economic environments to determine a policy for a society. It is also used in law enforcement models along with the application of the median voter theorem in these environments. In these models, in order to apply the median voter theorem either the single-peaked preferences or single-crossing property of preference profiles are assumed. In this paper, I demonstrate that these assumptions are often violated. Moreover, in law enforcement environments, agents cannot have opposite preferences over enforcement levels. These results imply that it may be necessary to rethink current approaches in economics of law enforcement.

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